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ABSTRACT

Children often have difficulty developing debugging skills. This may be attributable to instructional methods that discourage reflection on one's reasoning errors. Logo instruction may encourage such reflection. Two studies examined Logo's effect on confirmation bias--the tendency to select confirming over disconfirming information to prove an hypothesis. One study viewed elementary students while the second investigated college students. A third study investigated confirmation bias developmentally in grades 4 through 12. While Logo programming did not significantly effect deductive reasoning, elementary students exhibited an unusually high tendency to be disconfirmers while college students were confirmers. A significant difference was found in that twelfth graders more frequently selected confirming information than did fourth graders. This suggests that elementary students may be less resistant to learning self-reflective debugging skills than older students. Also, programming instructors may need to generate specific strategies to address confirmation bias in older students at the secondary school and university levels. (Author)

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DEDUCTIVE REASONING, LOGO AND THE SCHOOLS

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ABSTRACT

Children often have difficulty developing debugging skills. This may be attributable to instructional methods that discourage reflection on one's reasoning errors. Logo instruction may encourage such reflection. Two studies examined Logo's effect on confirmation bias - the tendency to select confirming over disconfirming information to prove an hypothesis. One study viewed elementary students while the second investigated college students. A third study investigated confirmation bias developmentally, grades 4 through 12. While Logo programming did not significantly ($p < .05$) effect deductive reasoning, elementary students exhibited an unusually high tendency to be disconfirmers while college students were confirmers. A significant difference ($p < .05$) was found in that twelfth graders more frequently selected confirming information than did fourth graders. This suggests that elementary students may be less resistant to learning self-reflective debugging skills than older students. Also, programming instructors may need to generate specific strategies to address confirmation bias in older students at the secondary school and university levels.

INTRODUCTION

Papert (ref 1) noted that students had difficulties developing debugging strategies and attributed children's difficulty to instructional methods used in formal schooling. He further suggested that experience with Logo could encourage the development of debugging skills. Recent research on strategy development suggests that failure to reflect on errors may have a significant impact on learning (ref 2). A related phenomenon, confirmation bias, has been studied in decision-making research. Wason and Johnson-Laird (ref 3) found that subjects predominantly selected positive or confirming information (rather than negative or disconfirming information) when testing the validity of IF p THEN q rules. Confirmation bias has been found across a wide variety of subjects (e.g., ref 4). Papert's observation that children had difficulty reflecting on errors may reflect a bias in children's deductive reasoning towards the avoidance of disconfirming information. Through formal schooling children may develop a bias for confirming information, while debugging requires consideration of disconfirming information. Logo may encourage the development of testing skills which reduce the negative affect associated with making errors and develop strategies that include the consideration of possible flaws in one's program.

OUTLINE OF STUDY AND METHODS

Study 1 included twenty-six 5th, 6th and 7th grade students from schools in the greater Toledo area who were attending a 5 week computer camp on Logo programming which met once a week for 2 hours. Study 2 included 46 college undergraduates enrolled in a "Computer Literacy for Educators" course. Study 3 was comprised of 39 public school students - 18 from grade 4 and 21 from grade 12.

In study 1, students received 8 hours of Logo instruction and were administered, as a pre-test and post-test, a confirmation bias task patterned after the four-card selection task developed by Johnson-Laird, Legrenzi, and Legrenzi (ref 5). In study 2, the college students in the experimental group ($N = 24$) received 9 hours of Logo instruction, while the control group ($N = 22$) received instruction on integrating computers into the curriculum.

Both groups were administered, as a pre-test and post-test, the instrument mentioned above. In study 3 each member of the sample received a version of the above cited instrument. Study 1 tested the hypothesis: Logo instruction causes a significant shift in

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student's reasoning from a confirming to a disconfirming strategy. Study 2 tested the same hypothesis and additionally the following: Adult students will exhibit an initial bias for the consideration of confirming information. Study 3 tested the hypothesis: Twelfth grade students will exhibit a significant tendency to select confirming information when compared to fourth grade students.

RESULTS

In study 1, no significant differences ($p < .05$) were found in data selection strategies before and after instruction using a chi-square test. In the table below, p, ~q represents the optimal data selection strategy. Note: 9 students did not complete the camp.

Table 1 Number of students using optimal data selection strategy

	Did not select p, ~q	Selected p, ~q
Before Instruction	23	3
After Instruction	14	3

However, it was noted that 15 of the 26 students (58%) did select disconfirming data (~q) prior to instruction, a tendency which remained essentially unchanged (10/17 for 59%) after instruction.

In study 2, no significant differences ($p < .05$) were found in data selection strategies when experimental and control groups were compared before and after instruction with two chi-square tests. However, when chi-square tests were used to compare the number of subjects selecting a confirming choice (p) and a disconfirming choice (~q) both before and after instruction, subjects in both groups tended to avoid disconfirming information both before (x^2 (1,46) = 7.53, $p < .01$) and after instruction (x^2 (1,46) = 6.16, $p < .05$). Table 2 illustrates the frequency of students selecting p and ~q before and after instruction. Also, a fairly low percentage, both before and after instruction, selected disconfirming (~q) data (30% before and 24% after).

Table 2 Undergraduates (all) selecting p, ~q before and after instruction

	(~q)	
(p)	Not Selected	Selected
Before Instruction		
Not Selected	4	7
Selected	28	7
After Instruction		
Not Selected	4	5
Selected	31	6

In study 3, a significant difference (x^2, (1,39) = 4.17, $p < .05$) was found between twelfth and fourth grade students who made confirming data selections (p, q) as illustrated in Table 3.

Table 3 Grade 4 vs. grade 12 - confirming choices (p,q)

	p,q		
	Not Chosen	Chosen	Total
Grade 4	11 (61%)	7 (39%)	18
Grade 12	6 (29%)	15 (71%)	21
Total	17	22	39

DISCUSSION

The results of study 1 suggest that contact with Logo may need to be longer than nine hours to significantly alter student's data selection strategies. A similar finding is in order for study 2. Also in study 2, undergraduate students significantly chose to avoid disconfirming data both before and after instruction. This is of interest since the majority of elementary students in study 1 selected disconfirming data (58% before instruction, 59% after). In contrast, only 30% of the undergraduates in study 2 made such selections before instruction and 24% after. While evidence (ref 3, 6) supports that students eventually develop strategies that avoid consideration of disconfirming information, the results of this study suggest that children can possess strategies that include consideration of disconfirming information even after seven years of formal education. It would be best to devise methods to help children maintain and develop those tendencies, rather than lose them. The results of study 3 further support this difference in data selection strategies. Significantly, twelfth graders in study 3 tend to choose confirming data more than do fourth graders. This may mean that instructors of high school and college-level programming need to address student's confirmation bias by using instructional methods that stress reflecting on program logic and errors. Linn and Dalbey's (ref 7) study of high school programmers offers some support for this suggestion.

Obviously more research, especially with larger sample sizes, is needed. However, despite the limitations of this study, some preliminary insights into confirmation bias and Logo have been gained.

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